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Comparison of Insulated Switch Gear with Desiccant Addition to SF6 Gas Quality System at Waru Substation

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ABSTRACT

Keywords
GSI
SF6
Moisture
Desiccant

In electrical instrumentality with SF6 gas insulation, the quality of SF6 gas in line with the standard is prime to wise insulation power, if there' a decrease in gas quality, there'll even be a decrease among the number of voltage insulation on electrical equipment. throughout this case, it had been found that the quality of SF6 gas was deteriorating within the Ganz whole GIS Compartment at the Waru Substation Substaction, specifically the position level of the SF6 isolation gas that exceeded the required standard limit. Besides, this GIS isn't equipped with silica gel/desiccant as a condition gripping material and gas sorbent material from amendment PMT (IEEE Std 11251993) that ends throughout a decrease among the standard of SF6 gas. The addition of drier among the GIS is needed to keep up the quality of SF6 gas. These materials are analyzed for quantity and performance once applied within the compartment therefore as that deterioration of the quality of SF6 gas and thus the prevalence of insulation failure is avoided as early as possible, and SF6 remains in its characteristics with a BDV of 78.6 kV/cm (according to SF6 crucial Breakdown Volatge). And it hoped that SF6 gas will add line with it operate as a decent insulating medium. As degree application, a drier experiment has been administered among the GIS compartment at the Waru Substation station.

1 Introduction

GIS (Gas Insulated Switchgear) is an important part of the generation system. GIS is a connecting system and power grid breaker as equipment installed in several circuits in a metal enclosure which using an insulating medium Sulphure Hexafluride gas (SF6) one of which is in the waru. GIS Waru Substation may be a very good one on one in each of the substations victimization SF6 gas insulation within the noble metal PLN Sidoarjo maintenance work house with four conductors associated 3 transformers [1]. This GIS ought to be usually monitored and maintained [2]. One of them is that the standard of your SF6 gas [3]. The customary take a glance at of SF6 gas distributed by PLN APP sidoarjo was supported and utterly was fully determined that this GIS is in a very important class due to the high condition of SF6 gas [4]. supported an investigation by PLN APP Sidoarjo, in addition found that this GIS isn't equipped with materials that will absorb wet from drying materials [5].

Comparison between different types of switchgear is very important in making the right decision for electrical system installation. This process involves evaluating the performance, reliability, safety features, cost-efficiency, and environmental impact of various switchgear options. By conducting a comprehensive comparison, it is possible to determine the most suitable type of switchgear based on factors such as voltage rating, current capacity, short-circuit breaking capability, and durability under different environmental conditions. The analysis work distributed by

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the author consists realize an answer to this status value by testing the drier within the GIS compartment, with the aim that this GIS can work with high reliability [6]. It is anticipated that the highest result the drier will greatly have an impression on the wetness of the SF6 and then the probability of an insulation failure within the GIS is typically avoided as quickly as possible [7].

2 Literature Review

2.1 Gas Insulated Switchgear (GIS)

Based on the IEV (International Electrotechnical Vocabulary) 441-11-02 switchgear itself [8], it' declared that the ultimate term includes switch devices and mixtures of control, measurement [9], protective/protective instrumentation where these devices have links or connections to accessories [10], compartments and supporting structures and in theory alleged to be used regarding the distribution/transmission, distribution and conversion of energy.

2.2 Gas Sulphure Hexafluride (SF6)

SF6 gas may be a gas that serves as a support for the insulation of the live components of the compartment or ground and this gas was chosen as a result of its varied benefits in comparison to alternative gases [11]. SF6 gas made worldwide is employed as an insulating medium in electrical systems. This can be thanks to the subsequent properties of SF6 gas.

Conductor heat (thermal conductivity) that is ready to dissipate heat that arises within the equipment [12]. Wonderful insulation (excellent insulating) [13]. Ready to extinguish arcs (arc) - Low viscosity [14]. Stable, challenging to react, good non conductor properties in SF6 due to the wide cross-sectional of the SF6 molecule and also the massive negatron affinity (Electronegativity) of the chemical element atom [15].

2.3 Desiccant

Desiccant are a few things that can absorb water vapor, serves to get rid of wetness in varied product that are sensitive to moisture and have various sorts cherish activated alumina, calcium sulfate air gel and others, whereas the molecular sieve is usually wont to remove moisture in gases [16].

2.4 Moisture

Moisture is that the water content within the variety of gas that reacts with other gases, the results of this reaction is the decrease in the worth of the insulation resistance in the main gas thanks to the conductive nature of the moisture [17].

Analysis Material: SF6 gas according to IEC 376 specification, GIS compartment [18]. Analysis tools: SF6 multi analyzer, regulator, SF6 gas leak check kit [19].

Analysis Location: At Waru Substation station and PLN APP Warehouse Sidoarjo. - the tactic employed in this study is by decisive: the number or quantity of drier material, determining gas pressure, and testing the humidness of SF6 gas in ppmv (parts per million by volume), additionally because the impact of this humidity level on the insulating power of SF6 gas in accordance with formula.

3 Method

3.1 Material Experiment Preparation

The preparation stage for the siccative material experiment within the GIS Compartment:

The desiccant experiment was apply based on the finding of high SF6 wet values in the Ganz whole GIS in Darmogrand GIS. Information on high humidity values in SF6 gas were found in compartments save for the breaker compartment (PMT) or CB (Circuit Breaker). Analysis on totaly different compartments with breaker (PMT), specifically the protection finish cable compartment and the bus bar compartment.

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The sealing end cable compartment and spare bus bar were use as check materials because of their similar design, shape, and construction to the prevailing Waru Substation GIS compartment. The compartment was then taken to prethermal extra} warehouse for further repairs, replacement of the o-ring seal, addition of a drier and preparation of gas filling (vacuum) and SF6 filling. Gas handling activities or gas-related activities, conform to the gas handling standards issued by the United States of America Environmental Protection Agency' handling procedures.

3.2 Material Technical Specifications

Sulfur hexafluoride (SF6) gas in step with IEC 376. The dryer with a pore diameter of four angstroms or 4 nanometers may be a Japanese molecular sieve kind. O-Ring Seal type NBR (Nitrile butyl Rubber) with a hardness (Hardness) of 70. Spare compartments fineom manufactured from product of fabricated from} aluminum, as well as T-shaped compartments or (T Tanks) with single-phase or single-phase GIS type per compartment.

4 Results and Discussion

4.1 Hardware

Technical Specifications of analysis Equipment:

a. Dillo whole Gas Handling with pressure capability of 30-40 Bar-40;
b. SF6 hose with a most pressure of 50 Bar;
c. Gas vacuum engine with vacuum power up to 0.5 mBar;
d. Gas test equipment SF6 SF6 Multi analyzer, and RH System 374;
e. SF6 regulator;
f. Gas Neppel Valve SF6 kind DN eight from Dillo and PN69 standard and stop faucets;
g. SF6 Gas leakage test Equipment, SF6 Dillo whole Leak Detector.

4.2 Testing

Mechanism of experiment and assembly of materials and tools:

a. Installation of the check compartment: The check Compartment that consists of 2 compartments is form into single half into one compartment in order that it is a bigger volume. The connecting a part of the compartment is replaced with a new seal to avoid leakage of SF6 gas, as well because the one on the compartment cowl. The bolts on the compartment cover are hardened with a torque of 60kN.

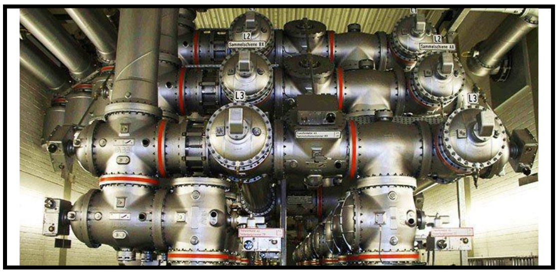

Fig 1. Compartment for Desiccant Trial

b. Determination of the desiccant weight: The weight of the desiccant material is weighed with a digital scale according to the calculation results, then the desiccant material is placed in a fabric container and sewn so that it is not spilled. In the compartment, the goal is for the material to react with the moisture in the compartment.

The formula for determining the desiccant weight in the compartment is as follows:

Desiccant force according to data sheet = 2021% w / w (the desiccant can absorb % of its total weight in 2021) to determine the adsorption capacity of the desiccant per x (gr).

X (gr) Desiccant = $\frac{20-21}{100}\ x\ Dessicant$

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The amount of moisture in the chamber is determined by calculating PPMV (parts per million per volume), which is converted into weight units using PPMW (parts per million per weight).

$$\frac{PPMV}{8,1} = PPMW \ or \ PPMV \ \times 8,1 = PPMV$$

8.1 is the ratio assumption of the molecular weight of air to SF6.

All test results in PPMV units are convert to PPMW (weight) units to convert to facilitate calculations or moisture calculations the unit used to represent PPMW is (mgr / kg).

$$\sum moisture1 = \frac{ppmv}{8,1}$$

$\sum moisture1 = amount\ of\ moisture\ per\ unit\ weight\ (PPMW)\ or\ (mgr/Kg).$

$PPMV \quad = moisture\ results$

(8,1) = molecular weight ratio of SF6 and H2O.

$\sum moisture2 \ = \sum moisture\ 1\ x \sum SF6$

$\sum moisture2$ = total amount of moisture in GIS compartment (mgr).

$\sum SF6 \quad = total\ amount\ of\ SF6\ gas\ (Kg).$

$$\sum desiccant = \frac{\sum moisture2}{daya\ absorsi\ (/gr)}$$

$\sum desiccant$ = total amount of desiccant needed (mgr).

$\sum moisture2$ = total amount of moisture in GIS compartment (mgr).

Adsorption adsorbs = desiccant ability to absorb moisture.

The price for the common GIS-Ganz subject is 16 grams, the experiment to be distributed later consists in using a chemical agent weighing 16 grams, half the ideal weight is 8 grams and double the ideal weight, that is 32 grams.

Fig 2. Desiccant material and its placement in the compartment

c. Aspirating the Chamber and Filling the Chamber with SF6 Gas: The next operation is the SF6 gas handling process, which must be done before filling the SF6 gas into the chamber. The process is a vacuum of the chamber. Put the motor on the Dillo motor and wait until it has reached a pressure of 0.5 mbar, then fill the SF6 gas from the line with a gas regulator to a pressure of 4.2 bar in chamber.

d. There are several things to consider when handling SF6 gas:

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- The vacuum process takes a long time due to the presence of gases from the air entering the compartment when cleaning or applying desiccant.
- If the vacuum meter has difficulties reaching a value of 0.5 mBar, there must be a suspicion of a leak in the lower chamber, it can also be checked whether it has been filled with SF6 gas, it is checked with a leak detector. The filling with
- SF6 gas takes place up to a pressure of 4.2 bar, adapted to the pressure in the Darmo grand GIS for the other compartment than the hammer (PMT).
- The chamber filled with SF6 gas at 4.2 bar normal pressure is checked again for gas leaks with an SF6 leak detector.
- The gas used for the experiment must first be tested with the SF6 gas test kit (SF6 multi-analyzer) or the RH system.
- The SF6 gas used must be of a quality in accordance with IEC 379 standards with a purity of 99.9%.

e. Monitoring the quality of the SF6 gas with regard to humidity and purity in the test room: This activity is carried out shortly after the room has been filled with SF6 gas at 4.2 bar normal pressure Determine the times for the next test (test break for 2 hours) The first test day was carried out over a full 12 hours and the additional test the next day with a total of two tests for one day. The test is the SF6 moisture content, the purity of SF6, the uptake of SF6 in the compartment. Figure 3 is the test result format for the desiccant experiment which was carried out for approximately 6 working days. Figure 3 inform form for purposed experiment. It table contain PPMV, PPMW, Purity, Dew Point, and pressure. Desiccant Weight According the calculation of the ideal weight of the desiccant. Test Result The appointment of the dillo brand SF6 multi analyzer test kit. Day 1 = 1st hour to 4 hours has a difference of 2 hours. Form day 2 is 1st hour to 2 hours has a difference of 12 hours.

Dessicant Weight	Test Result	Implementtation date															
		Day 1						Day 2		Day 3		Day 4		Day 5		Day 6	
		09:00	11:00	13:00	15:00	17:00	19:00	08:00	16:00	08:00	21:00	08:00	21:00	08:00	21:00	08:00	21:00
...gr	PPMV																
	PPMW																
	PURITY(%)																
	DEW POINT (DEG Celcius)																
	Pressure (bar rell)																

Information :
Dessicant Weight = According to the calculation of the ideal weight of the desiccant
Test Result = The appointment of the dillo brand SF6 multi - analyzer test kit
Day 1 1st hour to 4 hour has a difference of 2 hours
Day 2 1st hour to 2 hour has a difference of 12 hours
Day 2 - next day 1st hour to 2 hour has a difference of 12 hours

Fig 3. SF6 Gas Quality Testing Form During Desiccant Test Process

f. Closing procedure:

- All exams are taken on time and recorded in a specific format.
- The test room must be densely subdivided for each SF6 gas test.
- The monitored value is the moisture and purity value of the SF6 gas as a representation of the desiccant, regardless of whether the material works as expected or not. The desiccant.

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- The tested at different weights; H. with half the ideal weight and twice the ideal weight, using the same steps and procedures as described in the previous point.

4.3 Results

a. Desiccant weight for ladder Waru 1 phase T:

Before calculating the desiccant requirement, you must first know the humidity in each compartment; These data are the basis for determining the weight of the material that is then placed in the compartment as shown in table 1 (below refrence):

humidity (volume ratio) = 2613 PPMV

SF6 weight = 10 kg

desiccant absorption = 20% W / W

humidity (weight ratio) $= \frac{ppmv}{8{,}1} = \frac{1822.5}{8{,}1} = 225\ ppmw\ (mg/kg)$

Total moisture = $225 \frac{mg}{kg}$ x 10 kg = 2250 mg

The total amount of desiccant to be filled in the compartment is:

Desiccant amount = $\frac{\sum moisture}{daya\ absorbsi\ (/gr)}$

The weight of the desiccant to be filled into the chamber is 1.125 m² G.

b. Test results of a desiccant weighing 16 grams and its effect on the moisture of the SF6 gas. Table 2 describes the results of changing the humidity values from time to time and it can be seen that the humidity values decrease compared to without the use of desiccant.

Table 2. Test results on the effect of the desiccant weigh in 16 grams on the quality of SF6.

Dessicant Weight	Test Result	04/03/2015						05/03/2015		06/03/2015		07/03/2015		08/03/2015		09/03/2015	
		Day 1						Day 2		Day 3		Day 4		Day 5		Day 6	
		09:00	11:00	13:00	15:00	17:00	19:00	08:00	16:00	08:00	21:00	08:00	21:00	08:00	21:00	08:00	21:00
8 gr	PPMV	222	200.7	183.4	171.6	170.9	161.2	145	143.7	134.6	125.6	116.5	127.2	141.4	127.3	116.5	104.6
	PPMW	27.41	24.78	22.64	21.19	21.1	19.9	17.9	17.74	16.6	15.51	14.38	15.7	17.46	15.72	14.38	12.91
	PURITY(%)	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
	DEW POINT (DEG Celcius)	-35	-35.9	-36.7	-37.3	-37.4	-37.9	-38.8	-38.9	-39.5	-40.1	-40.8	-40	-39.1	-40	-40.8	-41.7
	Pressure (bar rell)	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2

If the results are displayed in graphical form it will be as shown in Figure 4 below:

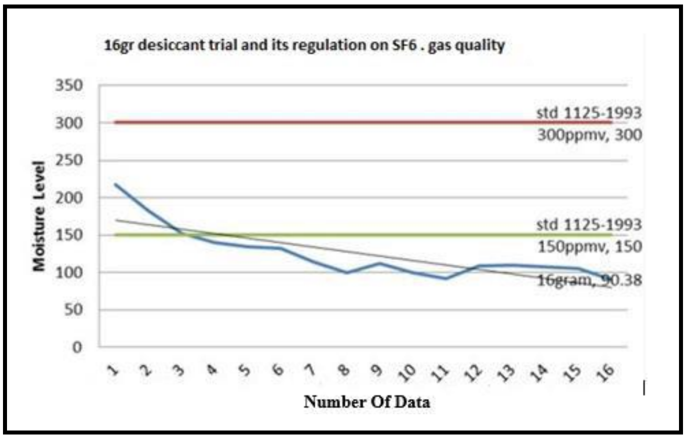

Fig 4. Graph of Desiccant Test Results weighing 16gr and its effect on the quality of SF6 gas.

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Figure 4 show the result on the effect of the descant weighin 16 gram on the quality of SF6 gas. The weight of the desiccant, 16 grams, can have an impact on the quality of SF6 (sulfur hexafluoride) in switchgear. Desiccants are used to remove moisture and maintain the dryness of the SF6 gas, as moisture can negatively affect its insulating and arc-quenching properties.

c. SF6 Gas Purity Results After Adding Desiccant

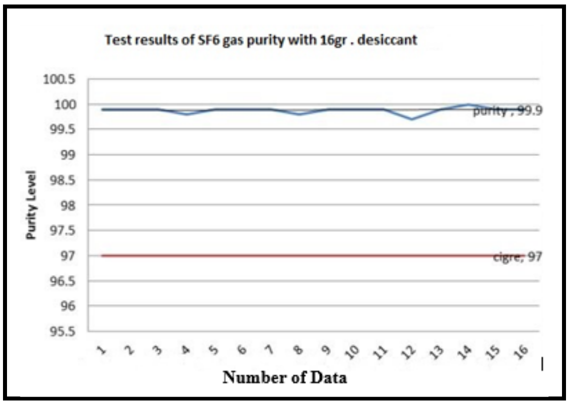

Fig 5. SF6 gas purity test result diagram with 16 g desiccant weight.

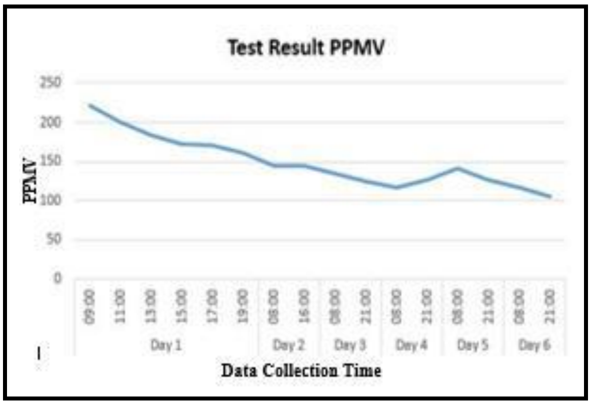

Fig 6. PPMV Trial Results

Figure 5 shows the change in the purity value of SF6 gas The SF6 gas purity value remains above 99% and remains standard. Based on Figure 6 it can be seen that the PPMV value decreased significantly over the time of data collection from the first day to the sixth day.

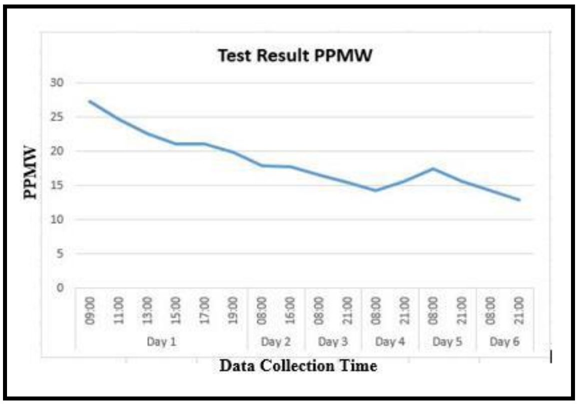

Fig 7. PPMV Trial Results.

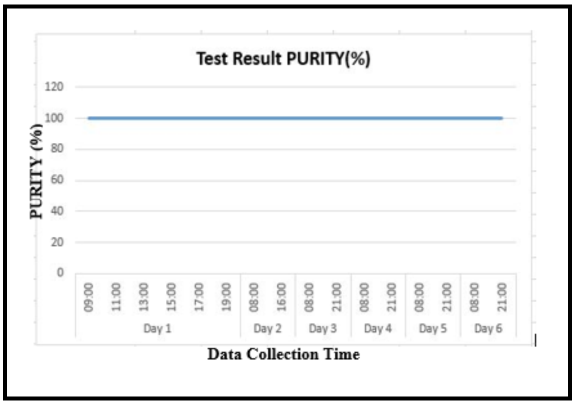

Fig 8. Purity (%) Trial Results.

As with PPMV, based on Figure 7, it can be seen that the PPMW value decreases significantly over time from the first day to the sixth day of data collection. based on the results of the purity test, it can be seen from Figure 8 that the level of purity of SF6 has not undergone any change, the level of purity of SF6 has remained at 99.9%.

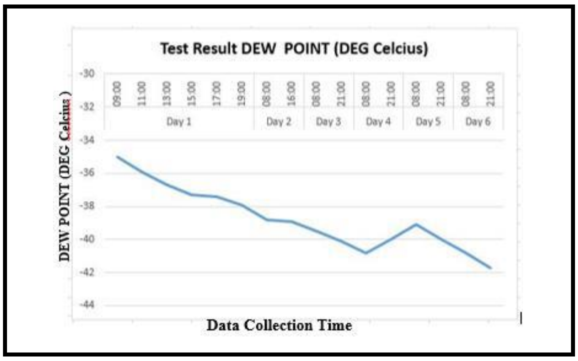

Fig 9. Dev Point (DEG Celcius) Trial Results.

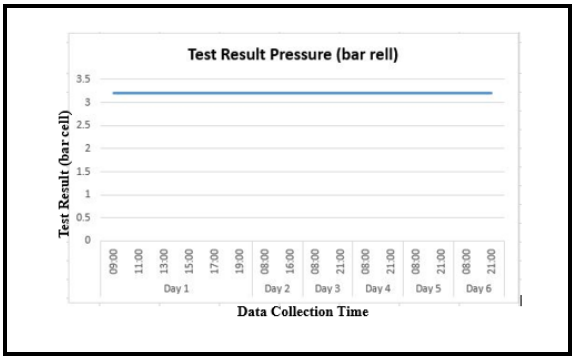

Fig 10. Pressure (Bar Rell) Trial Results.

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Based on Figure 9, it can be seen that the dew point at SF6 over the time of data collection, the dew point value decreases until on day 6 the dew point value is -41.7 Deg Celsius. based on the results of the pressure level test, the results obtained can be seen from Figure 10, namely the pressure value does not change and remains at a value of 12.

5 Conclusion

From the results and the discussion of the analysis it can be concluded that the desiccant was supplied to or applied to the GIS compartment in the gas-insulated switchgear from Waru Substation. The declaration of this material is very influential in reducing the water content in SF6 significantly. A value of 96.38% of Gas has been reached. An increase in the quality of the SF6 gas was observed in the moisture content value from the initial moisture content value at 2200 ppmv to a value of 80.18. SF6 gas is below the tolerance described above. According to IEEE 11251993, the moisture content in SF6 gas must be below 250 ppmv or 175 ppmv.

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Table 1. The initial moisture in the Darmo grand GIS indicated that it was the maximum moisture limit in the 1st Waru.

			1			2			3			4			5			6			7		
No	Component	Phase	Year 2009			Recycling Step on 2010												Year 2012			Year 2014		
						Before			1			2			3			4			5	6	7
			Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%	Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%	Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%	Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%	Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%	Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%	Dev Point °C @atm p	Volume Ratio PPMV	Volume SF6%
1	CT, Pms Line, PT, Pms Ground	R	-12.1	2136	98.2	-12.1	2136	98.2	-39.8	131	99.9	-34.7	228	99.9	-23.1	758	99.4	-13.1	1956	99.9	-22.4	810	88.8
		S	10.7	2426	98.1	-10.7	2326	98.1	-33.8	261.5	100	-32.9	310.1	99.9	-28.6	434.5	100	-13.8	1827	100	-23.3	600	100
		T	-9.9	2613	98.2	-9.9	2613	98.2	-34	246.6	100	-32.6	386.8	100	-32.3	296.1	100	-11.8	2196	100	-23.1	620	100
2	PMS Bus A. Bus Bar A	R	-8.1	3642	99.7	-8.1	3642	99.7	-32.6	286	100	-32	306	100	-28.6	435	99.9	-10.1	2564	100	-10.1	2568	88.8
		S	-5.9	3705	99.8	-5.9	3705	99.9	-33.1	270.6	99.9	-32.6	387.3	100	-30.5	357.9	100	-10.4	2917	100	-8.2	3026	88.6
		T	-7.9	3113	99.9	-7.9	3113	99.9	-32.4	293.4	100	-32.7	315.5	100	-29.6	419.9	99.9	-11.4	2425	100	-8.6	2687	88.7
3	CT, PMS Bus B, bus Bar B	R	-9	2833	99	-9	2833	99	-34.6	233	100	-32.9	277	100	-27.2	501	100	-10.7	2421	89.9	-10.7	2421	88.8
		S	-9.1	2808	99.9	-9.1	2802	99.9	-34.5	239	99.9	-33	273.7	100	-31.8	311.5	100	-10.4	2483	100	-10.4	2483	100
		T	-9.4	2978	99.3	-8.4	2978	98.2	-32.3	296.5	100	-32.1	303.4	100	-32.6	286.4	100	-11.4	2281	100	-11.4	2281	100

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